(2)

EVALUATION OF BAUER K220 HIGH PRESSURE BREATHING AIR COMPRESSOR

GEORGE D. SULLIVAN

MARCH 1990

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVSEA Task 89-11

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 6-90

EVALUATION OF BAUER K220 HIGH PRESSURE BREATHING AIR COMPRESSOR

GEORGE D. SULLIVAN

MARCH 1990

Submitted by:

G.D. SULLIVAN
GS-9
Test Director

Reviewed by:

J.W. MCCARTHY
GM-14
Hyperbaric Engineer

H.J.C. SCHWARTZ
CAPT, MC, USN
Senior Medical Officer

D.G. KIRBY
LCDR, CF
Fleet Projects Officer

K.A. HODINA
LT, USN
Acting Senior Projects Officer

J.B. MCDONELL
LCDR, USN
Executive Officer

Approved by:

J.E. HALWACHS
CDR, U.S. Navy
Commanding Officer

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF REPORT
DISTRUBUTION STATEMENT A: Approved for public release; distribution is unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
NEDU Report #6-90

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZ.
Navy Experimental Diving Unit

6b. OFFICE SYMBOL (If applicable)

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
Panama City, Florida 32407-5001

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
Naval Sea Systems Command

6b. OFFICE SYMBOL (If applicable)
00C

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)
Washington D.C. 20362-5101

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
		89-11	

11. TITLE (Include Security Classification)
BAUER K220 HIGH PRESSURE BREATHING AIR COMPRESSOR

12. PERSONAL AUTHOR(SO
SULLIVAN, David

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year,Month,Day)	15. PAGE COUNT
FINAL	FROM_____ TO_____	March 1990	15

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In response to reference (1) and as outlined in reference (2) Navy Experimental Diving Unit (NEDU) tested the BAUER K220 high pressure, breathing air compressor from November 14 thru 21, 1989. The purpose of this test was to determine if the equipment was suitable for use by the United States Navy (USN) diving community and if so, added to the Approved for Navy Use (ANU) Procurement List.

The BAUER K220 met manufacture's specifications for quantity of air produced with a quality which met or exceeded purity standards in reference (3). The design and engineering was determined to be adequate. With the inclusion of the recommendations in section V the BAUER K220 compressor is considered suitable for USN requirements for compressors of this size and type.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL

CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

In response to reference (1) and as detailed in reference (2), the Bauer K220 compressor was tested by NEDU. The test was to determine if the compressor discharged suitable breathing air and had a service life which satisfied the requirements for divers air supply compressors throughout the Navy. Other material variations were also evaluated and are listed as considerations in Section V.

Highly portable divers air compressors are designed to have high pressure with relatively how volume outputs. Divers require low pressure with high volume. The average divers high pressure air compressor is connected to large volume high pressure air storage flasks to meet this need. In normal operations the high pressure air is reduced to a lower pressure to act as a breathing media for divers. As this is accomplished, the pressure gradually reduces in the storage flasks. The compressors tend to run on a continous basis as the diving day continues because the demand is usually greater than the supply. At the end of the diving day or when air requirements are reduced, the compressors will exceed the demand and fill the air flasks.

There are various methods of testing compressor capacities. For the purposes of this compressor test, NEDU chose compressor testing consisted of charging from 0 to 2500 psig daily then opening the vent and maintaining 2000 to 2500 psig for continuous run. This method more closely simulated the use a compressor would experience in the field. Additionally during the continuous run, random charge rates were taken from 2000 to 2500 psig. The compressor was operated a total of 50 test hours. The testing included subjective evaluation of the system operation but did not include detailed mechanical review of the individual components of the system.

II. EQUIPMENT DESCRIPTION

The BAUER K220 high pressure, breathing air, compressor (Figures 1 thru 4) is a four stage, three cylinder design. The 1st and 2nd stage are housed in one common stepped cylinder. The three cylinders are arranged in a "W" configuration. The 1st/2nd stage cylinder is positioned vertically, the 3rd stage cylinder to the right, viewing from the flywheel. The 4th stage cylinder at the left side forms the second leg of the W arrangement.

The 1st/2nd stage and 4th stage cylinders are lubricated by means of the forced-fed lubrication system, the 3rd stage cylinder is splash-lubricated. The compressor requires approximately 8 quarts (US) of lubricating oil. The manufacturer recommends that only specific lubricants be used. These oils are not stocked in the Federal Supply System.

The K220 compressor block is used as a standard in the breathing air as well as in the industrial high pressure compressor units. It is particularly suitable for continuous operation because of its rugged design and the corrosion resistant intermediate filter and cooler assemblies.

The prime mover is a TOSHIBA 25 horse power, three phase 460 volt, 1765 RPM electric, motor, ser #9306796C, (see recommendation a). Rotational torque is transferred to the compressor by triple "vee" belts.

Filtration was accomplished by an intake filter cartridge, interfilters/moisture separators downstream of the 2nd and 3rd stages, a 4th stage water separator and a Pall Trinity filter immediately upstream of the charging whip. The automatic condensate drain unit drains the intermediate filters after the 2nd and 3rd stage, and the oil and water separator after the 4th stage every 15 minutes.

A pressure maintaining valve/non-return valve is provided down stream from the filter system to ensure that pressure build up occurs in the filters during start up and initial compressor air delivery. This achieves constant, optimum filtering, moisture separation and prevents compressed air from returning from the charged air storage tanks to the compressor during unit shut down.

All four stages of the compressor block are protected by safety relief valves.

Figure 5 provides an air flow disgram of the compressor and filter system. For these tests the BAUER final filter package was replaced with a Paul Trinity filter which is also available from BAUER upon request.

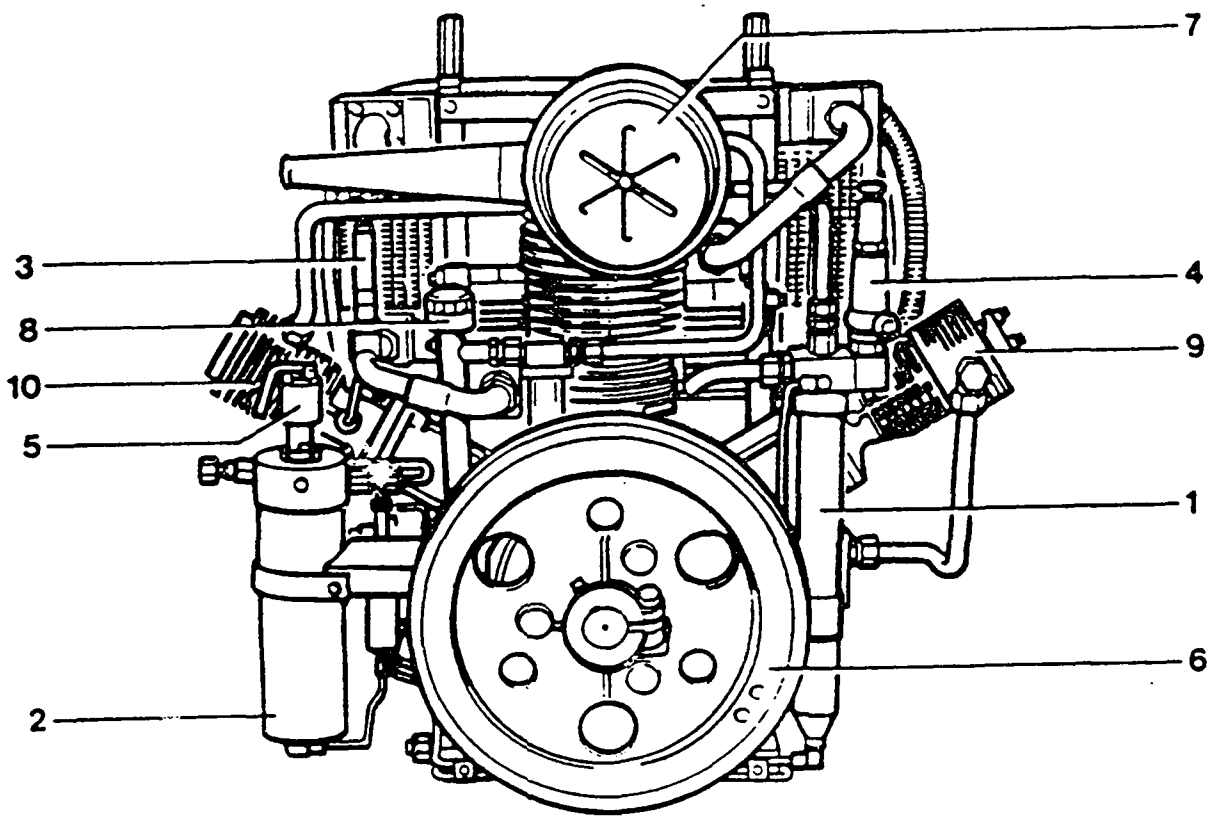

Fig. 1 Front View (Flywheel side)

1	Interfilter 3rd/4th stage	6	Flywheel
2	Oil and water separator	7	Intake filter
3	Safety valve, 1st stage	8	Oil filler neck
4	Safety valve, 3rd stage	9	Cylinder 3rd stage
5	Final pressure safety valve	10	Cylinder 4th stage

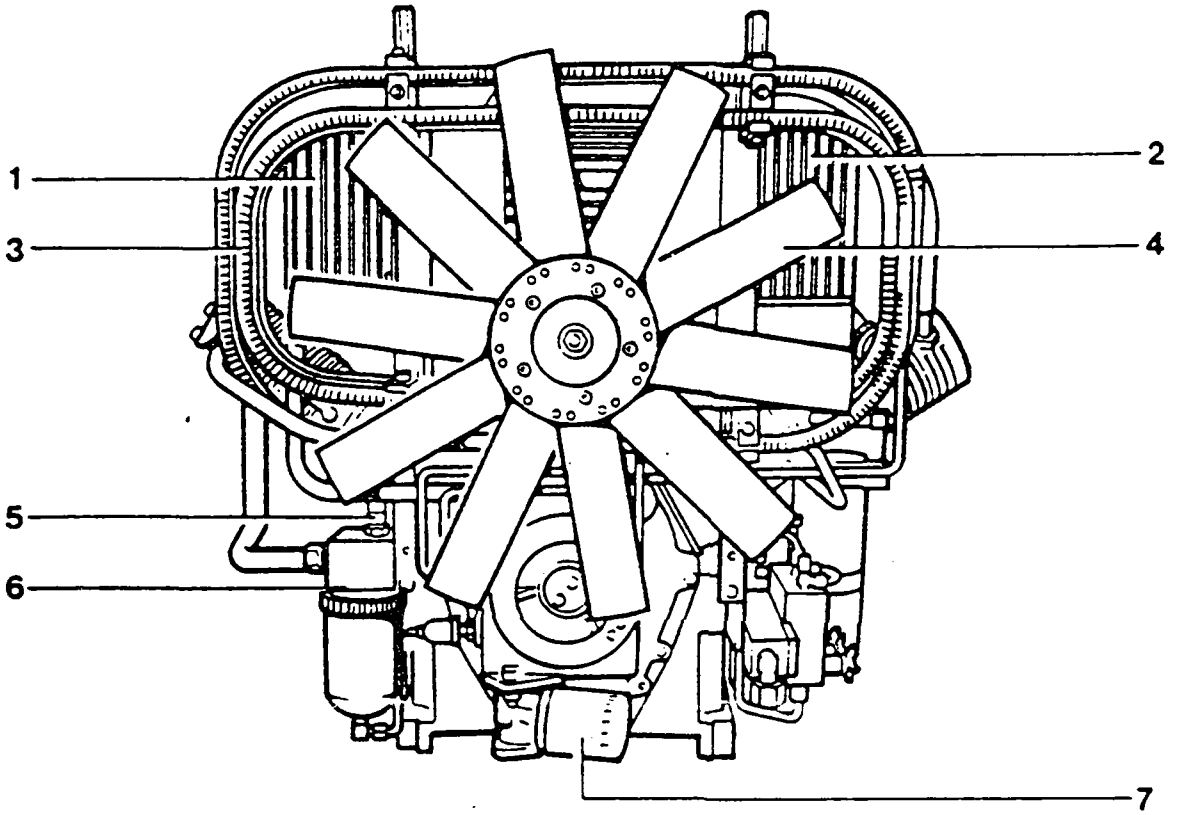

Fig. 2 Rear View (Fan-wheel side)

1 Inter-cooler 1st/2nd stage
2 Inter-cooler 2nd/3rd stage
3 Inter-cooler 3rd/4th stage and after-cooler
4 Fan-wheel
5 Safety valve, 2nd/3rd stage
6 Inter-filter 2nd/3rd stage
7 Oil filter

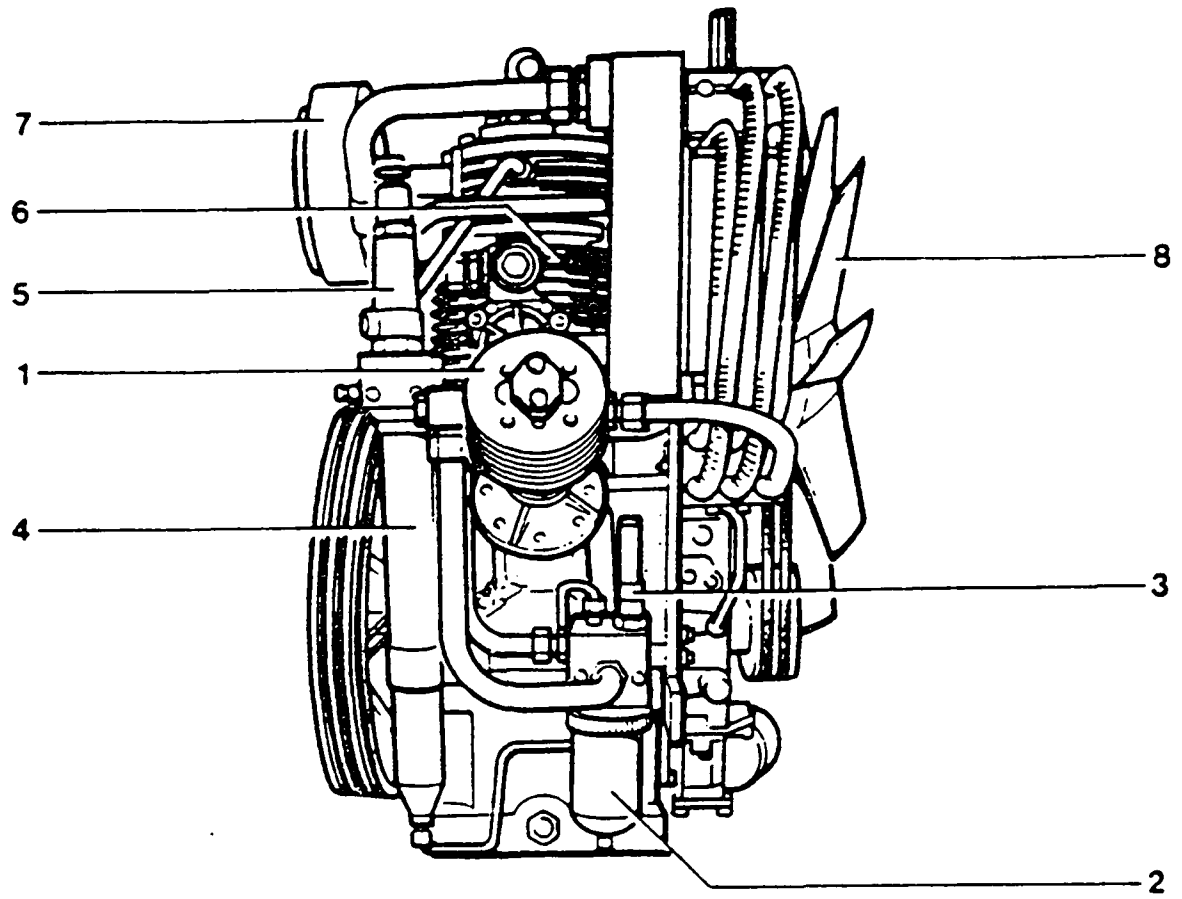

Fig. 3 Right hand side, viewed from flywheel

1 Cylinder 3rd stage
2 Inter-filter 2nd/3rd stage
3 Safety valve, 2nd stage
4 Inter-filter 3rd/4th stage
5 Safety valve, 3rd stage
6 Cylinder 1st/2nd stage
7 Intake filter
8 Fan-wheel

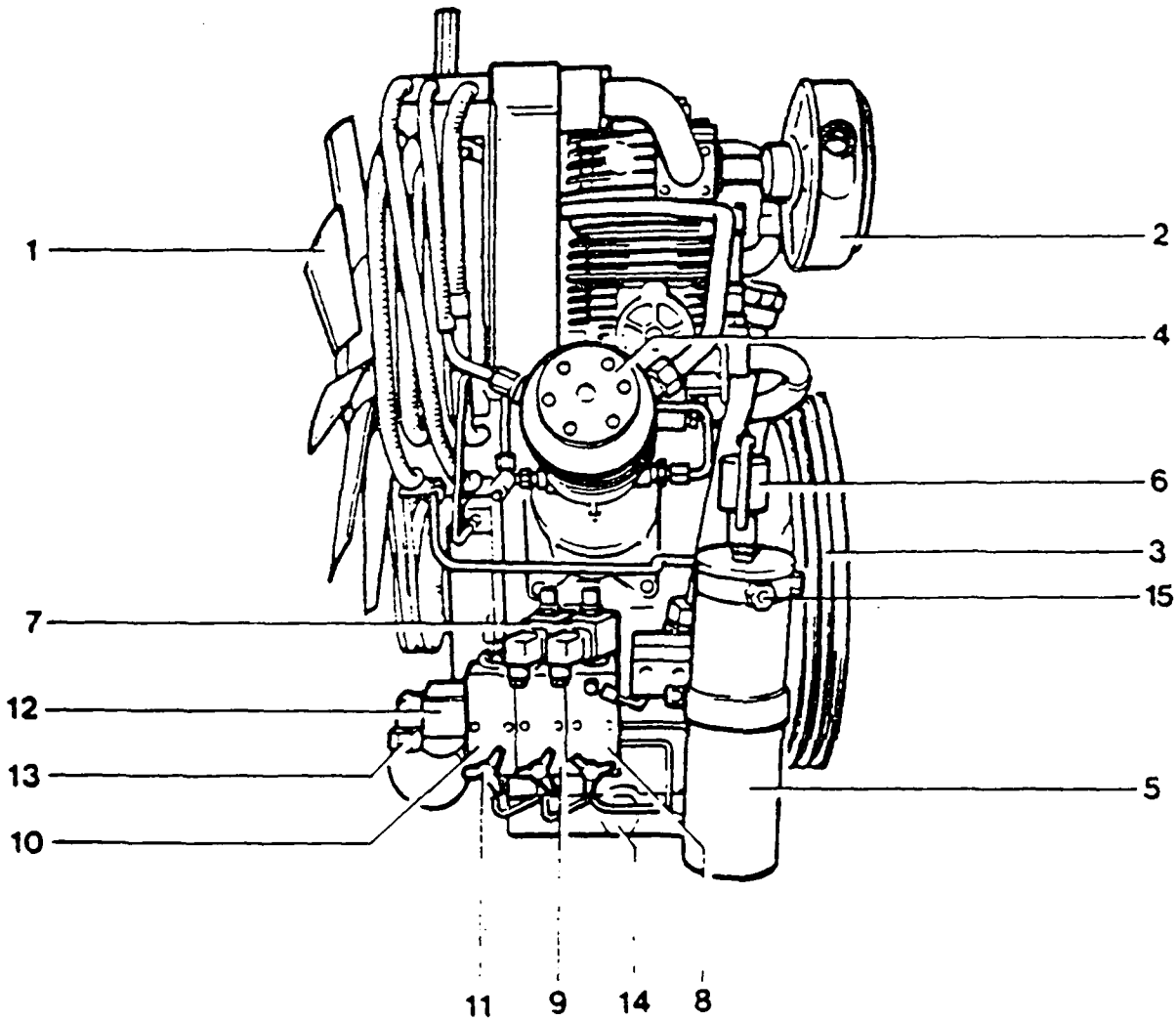

Fig. 4 Left hand side, viewed from flywheel

1 Fan-wheel
2 Intake filter
3 Flywheel
4 Cylinder 4th stage
5 Oil and water separator
6 Final pressure safety valve
7 3/2-way solenoid valve
8 Condensate drain valve, 4th stage
9 Condensate drain valve, 3rd stage
10 Condensate drain valve, 2nd stage
11 Manual condensate drain valve
12 Condensate manifold
13 Condensate outlet
14 Oil drain plug
15 Air outlet

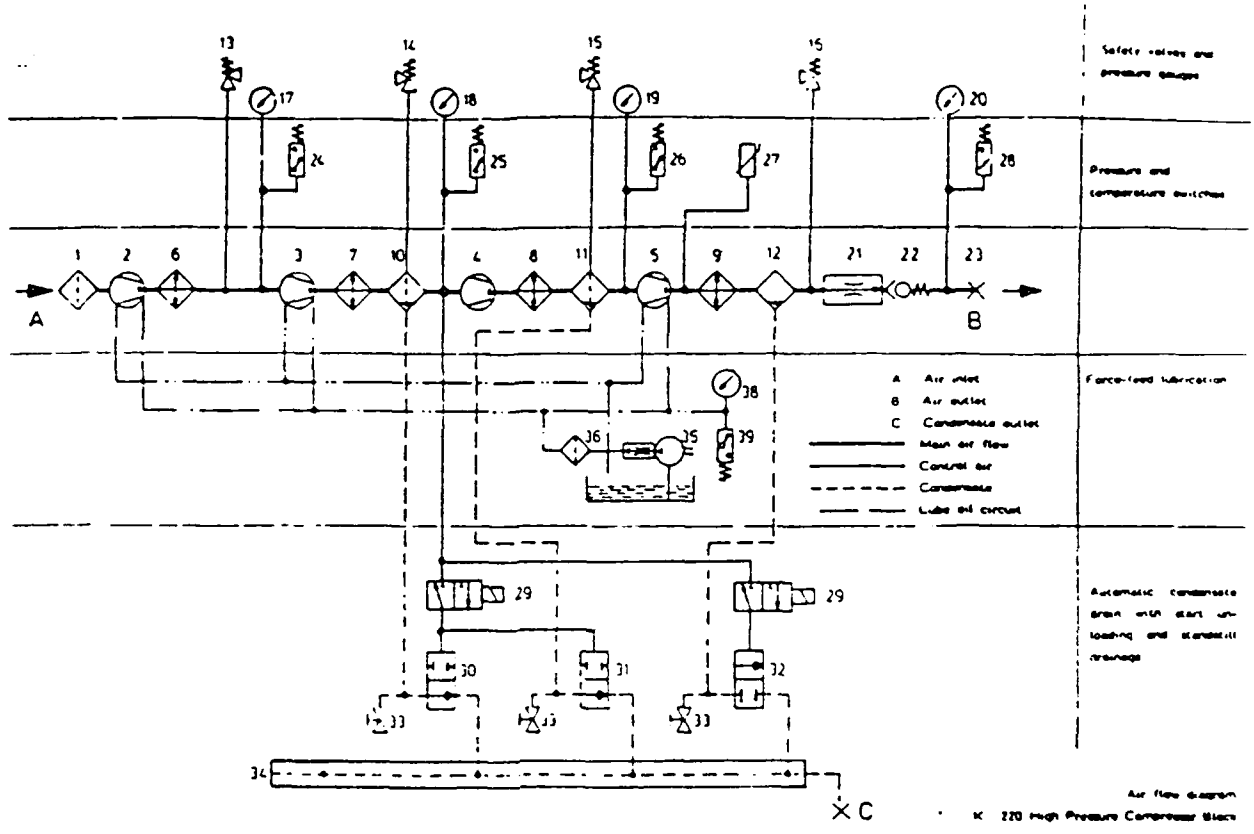

Fig. 5 AIR FLOW DIAGRAM

1 Intake filter
2 Cylinder 1st stage
3 Cylinder 2nd stage
4 Cylinder 3rd stage
5 Cylinder 4th stage
6 Inter-cooler 1st/2nd stage
7 Inter-cooler 2nd/3rd stage
8 Inter-cooler 3rd/4th stage
9 After-cooler
10 Inter-filter 2nd/3rd stage
11 Inter-filter 3rd/4th stage
12 Oil and water separator
13 Safety valve 1st stage
14 Safety valve 2nd stage
15 Safety valve 3rd stage
16 Safety valve 4th stage
17 Pressure gauge, intermediate pressure 1st/2nd stage
18 Pressure gauge, intermediate pressure 2nd/3rd stage
29 Pressure gauge, intermediate pressure 3rd/4th stage
20 Pressure gauge, final pressure 4th stage
21 Pressure maintaining valve
22 Non-return valve
23 Air outlet; connector for tube outer dia. 10 mm
24 Pressure switch, intermediate pressure 1st/2nd stage
25 Pressure switch, intermediate pressure 2nd/3rd stage
26 Pressure switch, intermediate pressure 3rd/4th stage
27 Temperature switch 4th stage
28 Final pressure switch.
29 3/2-way solenoid valve
30 Condensate drain valve 2nd stage
31 Condensate drain valve 3rd stage
32 Condensate drain valve 4th stage
33 Manual condensate drain valve
34 Condensate manifold
35 Oil pump
36 Oil filter
37 deleted
38 Oil pressure gauge
39 Oil pressure switch

III. TEST PROCEDURE

The compressor was set up in accordance with the manufacturer's instructions. A Cole Palmer model 8502-14 temperature monitor and Yellow Springs Instruments 700 series thermistor probes were attached to measure compressor discharge and ambient temperatures. A safety line was installed on the charging whip. The unit was placed in an exterior work area, open to ambient temperature but protected by an awning from direct weather. APPENDIX B contains the complete test plan and the pass/fail criteria used during the evaluation. APPENDIX C is the test log and contains the recorded data.

A. ENDURANCE TEST

The compressor was operated daily to charge four 2250 cubic inch (floodable volume) cylinders. The four cylinders were interconnected to simulate one large 9000 cubic inches air flask. After a charge of 2500 psig on the flasks the vent was opened to allow the compressor to run continuously at 2000 to 2500 psig discharge. A total of 50 hours of operation were logged on the compressor. The following parameters were recorded:

1. Date
2. Time
3. Total meter hours
4. Total test hours
5. Oil level
6. Oil pressure
7. All four stage pressures
8. Discharge air temperature
9. Ambient air temperature
10. Flask size
11. Flask pressure

B. CHARGE RATES

The volume of air delivered and the time to achieve that volume was logged on the average of three times per day and is recorded in Appendix C.

C. OIL CONSUMPTION

At the beginning of the test the oil sump level was measured as full. Oil level was monitored during operations and consumption logged. An oil change was accomplished at 25 hours of compressor operation. The oil used for the change was Anderol 750 (as per manufacturer's recommendations).

D. AIR SAMPLING

Air samples were taken from the compressor discharge at hours 1, 25 and 50 and sent to the NCSC Laboratory, Code 5130, for purity analysis.

E. MAINTENANCE

Scheduled maintenance was performed in accordance with the manufacturer's instructions and consisted of a lubricating oil and filter change at 25 total hours of operation. The oil sump level was checked prior to start-up each day.

IV. RESULTS

A. ENDURANCE TEST

The compressor was successfully operated a total of 50 hours to insure proper functioning and to draw air samples.

B. CHARGE RATES

The data collected provided a complete operational and maintenance log for this test and was the basis for computing and evaluating all the test results. Compressor charge rates for the air cylinders used during the test were as follows:

	TIME	TOTAL VOLUME	CHARGE RATE
MINIMUM:	4 MINUTES 53 SECONDS	177 CUBIC FEET	36.2 SCFM
MAXIMUM:	4 MINUTES 28 SECONDS	177 CUBIC FEET	39.6 SCFM
AVERAGE:	4 MINUTES 42 SECONDS	177 CUBIC FEET	37.65 SCFM

NOTE: Differences in maximum and minimum charge rates were the result of gauge fluctuation that caused difficulty in reading the minute pressure indications on the gauge used for this particular test.

The majority of the temperature differentials between ambient and compressor discharge temperatures were 12 to 17 degrees Fahrenheit. The maximum recorded differential temperature was 22 degrees Fahrenheit. This minor carry over of the heat of compression is not great enough to have significant effect on the resulting air cylinder temperature.

C. OIL CONSUMPTION

During the test the compressor consumed one quart of oil. Average consumption was 0.04 pints per hour and is considered acceptable.

D. AIR SAMPLING

The results of the air samples is shown in APPENDIX D. All samples were within limits established by reference (3).

E. MAINTENANCE

The Bauer K220 compressor unit was easily maintained and only minor problems were encountered. The maintenance manual for the compressor is considered adequate.

NOTE: During start up on day 2 (test hr 7) with an ambient air temperature of 51 degrees Fahrenheit, a problem was encountered with the low oil pressure switch. The switch had to be re-adjusted to a lower cut off pressure. This allowed continuous running until the oil sufficiently warmed up and the 40 second timed relay delay could shift to automatic. (See recommendation B.)

NOTE: At 28 hours into the test the air pressure switch failed to function at the preset pressure and had to be re-adjusted. This is considered to be a minor problem. Whereas the operating procedures would take into consideration the fine tuning of the pressure switch prior to operation.

V. RECOMMENDATIONS

The following are recommended considerations that the user should be aware of when purchasing this compressor.

Depending on the specific use and environment it may be prudent to have the manufacturer make the recommended changes prior to purchasing the compressor.

A good example of this would be if the compressor was going to be used inside a protected area the recommendations would not apply as much if it was going to be used out in the weather.

These are only considerations and not requirements.

RECOMMENDATION

A. Primary power source be changed to meet specifications standards of MIL-M-17060-E Amendment 1.

JUSTIFICATION

In accordance with reference 5 to meet Navy specifications the prime mover, if electric, should be a Sealed insulation system (service A use) in accordance with MIL-M-17060 E, Amendment 1.

RECOMMENDATION

B. The oil sump heating device be installed in all US Navy purchased BAUER K220 compressors.

JUSTIFICATION

Since 51 degrees is a moderate temperature, it is recommend that the oil heating devices available from BAUER, be installed in BAUER K220 compressors purchased by the US Navy.

RECOMMENDATION

C. The cadmium coated fittings be replaced with a suitable substitute.

D. JUSTIFICATION

Reference (4) states that cadmium coated fittings cannot be used in systems that exceed 400 degrees Fahrenheit or if the cadmium could come in contact with petroleum products. At this time the only authorized HP compressor lubricant by the Navy is 2190-TEP.

VI. CONCLUSIONS

Evaluation of the BAUER K220 compressor revealed the following

1. The BAUER K220 compressor delivers acceptable breathing air at a charge rate and volume which meet's or exceeds the manufacture's specifications.

2. The unit is sturdy, reliable and readily maintainable.

3. The operating and maintenance manuals for the compressor are adequate.

4. The BAUER K220 compressor is suitable for use by the US Navy.

REFERENCES

1. NAVSEA Task 89-11; Testing of commercially available air compressors for divers use for ANU list.

2. Test Plan Number 89-48; Operational Evaluation of Divers High Pressure Air Compressor.

3. NAVSEA 0994-LP001-9010, U S Navy Diving Manual Vol 2, Para 5.3.2 Air purity standards.

4. Navy Publication No. S9AA-AA-SPN-010/GENSPEC of Jan 19, 1987. General Specifications for Ships of the Navy, Cadmium Fittings

5. MIL-M-17060 E, Amendment 1, Sealed insulated systems, (service A use). Navy specifications for compressor power source.

MANUFACTURE'S TECHNICAL

SPECIFICATIONS

Model		K22.0 (mod. 3)
Operating pressure	max. bar (psi)	350 (5,000)
Delivery	l/min (c.f.m.)	650...930 (23...33)
Speed	min^{-1}	980...1320
Power requirement	kW	14.5...20.5
Req'd motor	kW	15...22
No. of stages		4
No. of cylinders		3
Cylinder diameters	mm (in.)	
1st stage		130 (5.11)
2nd stage		130/110 (5.1/4.3)
3rd stage		36 (1.4)
4th stage		16 (.63)
Piston stroke	mm (in.)	80 (3.15)
V-belt pulley diameter	mm (in.)	450 (17.7)
V-belt profile		3 x SPA
Sense of rotation, viewing at flywheel		ccw
Cooling system		air
Lubricating system		pinion gear driven oil pump
Lube oil pressure	bar (psi)	2...3 (28...43)
Lube oil capacity, approx.	l (US qts.)(Imp.gal.)	8.0 (8.5) (2.1)
Intermediate pressures (approx. values at max. op. press.)		
1st stage	bar (psi)	3 (43)
2nd stage	bar (psi)	13 (188)
3rd stage	bar (psi)	68 (965)
Max. allowable inclination		10° to all sides
Condensate drain		Automatically every 15 minutes
Weight	kg (lbs.)	300 (660)
Air outlet tube dia.	mm	10

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:
NAVSEA Task 89-11

NAVY EXPERIMENTAL DIVING UNIT

STANDARD TEST PLAN

OPERATIONAL EVALUATION OF DIVERS HIGH PRESSURE AIR COMPRESSORS

TEST PLAN NUMBER 89-48

NOVEMBER 1989

Submitted:

T.D. SULLIVAN
GS-9
Test Director

Reviewed:

J.W. McCARTHY
GM-14
Hyperbaric Engineer

H.L. PRUITT
LCDR, USN
Senior Projects Officer

J.B. McDONELL
LCDR, USN
Executive Officer

Approved:

JAMES E. HALWACHS
CDR, USN
Commanding Officer

DISTRIBUTION: Codes 00, 01, 03, 05
Original to Technical Library

RECORD OF CHANGES

Except as provided for herein, changes will be made only on the authority of the Commanding Officer, NEDU. A dark vertical line in the left-hand margin indicates the coverage of change.

CHANGE NO.	AUTHORITY	INSERTION	SECTION	INITIAL

TABLE OF CONTENTS

References:

(a) NAVSEA Task 89-11
(b) NEDU Test Plan Number 80-37, Bauer Portable High Pressure Air Compressor
(c) NCSC Field Test Procedure SP80-13-OS6 for Testing Diving Air Compressors
(d) Bauer Compressors Instruction Manual OPM-4
(e) Bauer Compressor Instruction Manual for the K220
(f) NEDU Report 11-83, Evaluation of Bauer Mariner "D" High Pressure Breathing Air Compressor

1. Introduction. This test plan provides a series of procedures for standardized evaluation of commercially available divers high pressure air compressors. The compressors will be evaluated and data compiled during these tests to determine their suitability and reliability and eventual Approval for Navy Use (ANU).

Reference (a) directed NEDU to survey the commercial domestic market to determine if currently available high and low pressure compressors are applicable for fleet use. If applicable, procure compressor systems as required for evaluation. Make recommendations for inclusion on ANU listing.

2. Test Parameters. Evaluation of the compressor will be conducted as follows:

a. Conduct inspection of compressor using manufacturers instruction manuals [references (d) and (e)] to ensure all parts and material are received and on hand.

b. Using the manufacturers technical manual for the specific air compressor and its components, inspect for and determine if the following items exist and/or comply, and record results and comments in ANNEX A.

(1) All instruments and controls are clearly and permanently marked according to their functions.

(2) All controls, gauges and indicators necessary for operation of the compressor are visible and convenient to the operator.

(3) Safety devices are provided and audible and/or visual warning functions as specified.

(4) Liquid level indicators accurately display liquid level.

(5) All removable components can be removed and properly reinstalled in working conditions using the manufacturers operating manual, i.e. filters.

(6) All drain, traps and safety valves discharge ports will function without splashing, are conveniently located, and are away from operating personnel.

c. Have all instrumentation provided by manufacturer compared for accuracy.

d. Operate the compressor for one hour under a no load condition.

e. Take and analyze air samples following no load test run.

f. Conduct testing in accordance with the procedures set forth in Section 4. Total compressor running time will be 50 hours.

3. Preliminary Arrangements

a. Arrange for photographic support.

b. Arrange for air analysis as required.

c. Arrange for all instrumentation to be compared by calibration facility.

d. Prior to the actual test procedure the air compressor system shall be operated then shut down when the system is at maximum pressure and the following steps accomplished.

(1) Hold pressure.

(2) Allow the system to cool to ambient temperature, and conduct a 90 minute drop test as follows:

(a) After temperature has stabilized, record the storage flask pressure.

(b) After 90 minutes, record pressure again.

(3) Leak rate shall be zero.

4. Test Procedure. The following test procedures will be conducted as specified, and the results entered in the log sheets, ANNEX A.

a. Take air samples at hours 1, 25, 50 and anytime air quality is questioned.

b. Log the following measurements on the log sheet, ANNEX A.

(1) Date

(2) Time

(3) Compressor meter hour (if applicable)

(4) Total hours running time on compressor (this test)

(5) Compressor oil level

(6) Compressor oil pressure

(7) First stage pressure

(8) Second stage pressure

(9) Third stage pressure

(10) Fourth stage pressure

(11) Discharge air temperature

(12) Ambient air temperature

(13) Flask size and pressure

(14) Remarks

c. The compressed air system shall be set to cycle 10 times per hour by adjusting controls and bleed off rate.

d. Compute volume output of the compressor by charging a known volume storage flask to 3000 psig. Log total charging time and calculate charging rate.

e. Oil consumption shall be measured and recorded during testing, with measurements and additions entered in the log.

f. Perform maintenance as required by the manufacturers instruction manuals.

5. Safety Rules and Emergency Procedures. Safety rules and precautions as outlined in the specific manufacturers instruction manuals.

6. Termination Criteria. The following is failure criteria for the suitability for the specific compressor system for ANU.

a. Failure of any component which cannot be corrected in accordance with the recommended schedule of maintenance.

b. Failure of the diving air system to operate as specified by the manufacturers instruction manuals.

c. Failure of the valves to operate as specified.

d. Failure of the pressure relief valves to operate as specified.

e. A decrease in capacity of the compressor during this performance evaluation.

f. A discharge air temperature from any cylinder in excess of manufacturers specifications or recommendations.

g. Failure of the air samples to pass breathing air specifications.

7. Personnel Requirements. NEDU Hyperbaric Department and/or Test and Evaluation Division personnel (one each).

8. Logistic Support

a. Photographic support.

b. Gauge calibration.

c. Air analysis.

9. Control and Safety of Systems. The NEDU Task Leader and Test director are responsible for the control and safety of systems. All control systems, safety systems and valves shall be activated by making the necessary temporary alterations to the compressor controls and operations whenever such alterations will not result in a risk of damage to the compressor unit. Where a risk is present, the test may be conducted with control systems completely removed from the compressor unit by subjecting control system sensors to other sources of temperature and pressure; for example, the oil safety switches and sensors, automatic condensate blow down valves overpressure switches and sensor, high temperature switches and sensors, and other devices designed to operate or protect the system and attending personnel.

10. Post Test Arrangements. Make all necessary arrangements as previously determined to return compressors system and test fixtures to proper locations.

11. Report Production. Test report and camera ready copy to be written and prepared by the Test Director and submitted for approval to the Commanding Officer via the Task Leader. Estimate publication date is six weeks following completion of testing. Test Directors will be the point of contact for NEDU concerning this test and will be appointed by the Task Leader.

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
14 NOV	11:15	6.9	0	FULL	0	0	0	0	1400	75.6	74.8		0	START TEST
	11:25	6.9	0		34	45	190	800	1400	47.7	74.4		1000	
	12:30	7.9	1		36	45	190	800	2000	51.1	78.9		1800	1 HR AIR SAMPLE
	13:30	8.9	2		36	45	190	800	2500	55.4	77.6	5.2	2500	2000 TO 2500 4 MINS 46 SECS 37.1 ACFM
	14:15	9.4	2.5		36	45	185	900	2500	87.7	77.6		2500	
								STOP TEST						
15 NOV	07:05	9.4	2.5		36	45	189	875	2500	74.3	71.6	5.2	2500	2000 TO 2500 4 MINS 43 SECS 37.5 ACFM
	07:45	9.9	3		36	45	180	900	2200	81.5	73.1		2200	
	09:22	10.9	4		36	45	180	900	2500	91.4	73.2		2500	
	10:31	11.9	5		36	45	180	900	2500	92.1	75.8	5.2	2500	2000 TO 2500 4 MINS 36 SECS 38.4 ACFM
	11:42	12.9	6		36	45	180	900	2100	90.7	76.1		2100	
	12:51	13.9	7		36	45	180	900	2500	91.3	76.2		2500	

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
16 NOV 89	07:00	13.9	7	*1/8"	26	45	180	875	2100	50.4	51.3		0	OIL PRESSURE SWITCH PROBLEM
	08:00	14.9	8		34	45	180	880	2500	51.8	52.1	5.2	2500	2000 TO 2500 4 MINS 42 SECS 37.6 ACFM
	09:14	15.9	9		34	45	180	900	2500	70.2	55.1		2500	
	10:18	16.9	10		34	45	180	875	2100	66.7	58.8		1755	
	11:30	17.9	11		34	46	180	875	2500	62.8	63.9	5.2	2500	2000 TO 2500 4 MINS 33 SECS 38.8 ACFM
	12:36	18.9	12		34	46	180	900	2400	73.9	68.3		2400	
	13:40	19.9	13		34	46	180	875	2200	72.5	68.6		2150	SECOND STAGE GAUGE FOGGED UP
	14:46	20.9	14		34	46	180	880	2500	70.3	64.5		2500	
	15:10	21.9	15		34	46	180	900	2300	69.6	57.3		2200	
16 NOV 89	17:30	22.9	16		34	46	180	900	2500	70.3	53.6	5.2	2500	2000 TO 2500 4 MINS 53 SECS 36.2 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
17 NOV 89	06:00	22.9	16	*1/4"	30	45	180	875	2100	26.3	37.8	5.2	1000	
	06:15	23.2	16.15		32	45	180	900	2500	54.4	37.6	5.2	2500	2000 TO 2500 4 MINS 28 SECS 39.6 ACFM
	07:10	23.9	17		34	45	180	875	2200	51.6	40.3		1800	
	08:18	24.9	18		34	45	180	900	2200	47 8	41.1		1950	
	08:24	25	18:06		34	46	180	900	2100	47.7	41.4		1250	STOP TEST 25 COMPRESSOR HRS OIL CHANGE &
	11:15	25	18:06	FULL	42	46	180	900	2200	32	52.1		1250	FILTER FL-400A ANDROL 750
	12:20	25.9	19		38	46	180	900	2500	65.9	52.3	5.2	2500	2000 TO 2500 4 MINS 31 SECS 39.2 ACFM
	13:32	26.9	20		36	46	180	900	2100	69.7	56.6		1750	
	14:43	23.9	21		36	46	180	900	2500	65.3	53.9		2500	
	15:50	28.9	22		36	46	180	900	2100	61.2	51.7		1600	
17 NOV 89	17:12	29.9	23		36	46	180	900	2500	66.3	50.2	5.2	2500	2000 TO 2500 4 MINS 38 SECS 38.2 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
20 NOV 89	05:30	29.9	23	FULL	36	45	180	875	2100	52.1	53.2		2000	
	05:36	30	23:06		36	46	180	900	2500	66.9	53.2	5.2	2500	2000 TO 2500 4 MINS 46 SECS 37.1 ACFM
	06:41	30.9	24		36	46	180	875	2100	42.1	52.4		800	
	07:41	31.9	25		36	46	180	900	2400	71.1	62.7		2400	25 HR TEST AIR SAMPLE
	08:50	32.9	26		36	46	180	900	2500	78.5	68.1		2500	
	09:12	33.9	27		36	46	180	900	2500	81.1	65		2500	
	10:18	34.9	28		36	46	180	900	2600	83.7	70.6		2600	HAD TO RESET PRESSURE SWITCH
	11:40	35.9	29		38	46	180	900	2500	86.8	71.4	5.2	2500	2000 TO 2500 4 MINS 42 SECS 37.6 ACFM
	13:00	36.9	30		38	46	180	890	2100	75.2	72.6		1650	
	14:08	37.9	31		38	46	180	890	2300	76.7	73.4		2250	
	15:10	38.9	32		38	46	180	890	2000	75.2	66.9		1500	
	16:20	39.9	33		38	46	180	890	2100	73.9	65.3		1900	
20 NOV 89	17:30	40.9	34		38	46	180	890	2500	72.5	64.7	5.2	2500	2000 TO 2500 4 MINS 39 SECS 38.0 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
21 NOV 89	05:30	40.9	34	FULL	36	46	180	890	2000	59.1	62.5		1000	HAD TO RESET BACK PRESSURE
	06:45	41.9	35		36	46	180	900	2500	78.6	63.3	5.2	2500	REGULATOR 2000 TO 2500 4 MINS 45 SECS 37.2 ACFM
	08:04	42.9	36		38	46	180	900	2500	82.5	70.2		2500	
	09:10	43.9	37		38	46	180	900	2500	85.9	76.7		2500	
	10:20	44.9	38		38	46	180	890	2100	88.2	81.4		1600	
	11:30	45.9	39		38	46	180	900	2500	75.7	80.1		2150	
	12:40	46.9	40		38	46	180	900	2500	92.4	77.9	5.2	2500	2000 TO 2500 4 MINS 43 SECS 37.5 ACFM
	13:44	47.9	41		38	46	180	900	2500	90.3	76.4		2400	
	15:00	48.9	42		38	46	180	900	2100	72.6	73.3		1000	
	15:14	49.9	43		38	46	180	900	2500	91.2	73.1		2500	
	17:12	50.9	44		38	46	180	900	2500	87.3	69.9		2400	
21 NOV 89	18:15	51.9	45		38	46	180	900	2500	80.8	67	5.2	2500	2000 TO 2500 4 MINS 44 SECS 37.3 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
22 NOV 89	05:30	51.9	45	ADD ONE PINT	36	45	180	875	2000	62.7	69.4		1000	
	06:40	52.9	46		38	45	180	900	2500	78.9	64.8	5.2	2500	2000 TO 2500 4 MINS 44 SECS 37.3 ACFM
	07:42	53.9	47		38	46	180	900	2250	82.8	68		2000	
	08:54	54.9	48		38	46	180	900	2500	86.4	71.7		2500	24 HR AIR SAMPLE
	10:00	55.9	49		38	46	180	900	2100	88.5	72.1		2000	
	11:15	56.9	50		38	46	180	900	2500	86.1	72.3	5.2	2500	2000 TO 2500 4 MINS 41 SECS 37.7 ACFM
														TOOK 50 HRS AIR SAMPLE

1 HOUR

Memorandum 15 Nov 1989

To: Dave Sullivan, EDU
From: Glen Deason, Code 5130

Subject: Results of air sample from Bauer compressor. This was the one hour test. Test number 89-48.

1. In accordance with your request, on 15 Nov 1989 the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	362 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	3.4 PPM
Total Halogens**	<0.5 PPM
Methane	3.4 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

Memorandum 20 Nov 1989

To: Dave Sullivan, EDU
From: Glen Deason, Code 5130

Subject: Results of air sample from Bauer compressor. This was the twenty-five hour test.

1. In accordance with your request, on 20 Nov 1989 the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	392 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	3.6 PPM
Total Halogens**	<0.5 PPM
Methane	3.6 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.3 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

Memorandum 27 November 1989

To: Dave Sullivan, NEDU
From: Glen Deason, Code 5130

Subject: Test results of air sample from Bauer compressor after 50 hours.

1. In accordance with your request on 27 Nov 1989, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	348 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	2.1 PPM
Total Halogens**	<0.5 PPM
Methane	2.1 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
14 NOV	11:15	6.9	0	FULL	0	0	0	0	1400	75.6	74.8		0	START TEST
	11:25	6.9	0		34	45	190	800	1400	47.7	74.4		1000	
	12:30	7.9	1		36	45	190	800	2000	51.1	78.9		1800	1 HR AIR SAMPLE
	13:30	8.9	2		36	45	190	800	2500	55.4	77.6	5.2	2500	2000 TO 2500 4 MINS 46 SECS 37.1 ACFM
	14:15	9.4	2.5		36	45	185	900	2500	87.7	77.6		2500	
								STOP TEST						
15 NOV	07:05	9.4	2.5		36	45	189	875	2500	74.3	71.6	5.2	2500	2000 TO 2500 4 MINS 43 SECS 37.5 ACFM
	07:45	9.9	3		36	45	180	900	2200	81.5	73.1		2200	
	09:22	10.9	4		36	45	180	900	2500	91.4	73.2		2500	
	10:31	11.9	5		36	45	180	900	2500	92.1	75.8	5.2	2500	2000 TO 2500 4 MINS 36 SECS 38.4 ACFM
	11:42	12.9	6		36	45	180	900	2100	90.7	76.1		2100	
	12:51	13.9	7		36	45	180	900	2500	91.3	76.2		2500	

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
16 NOV 89	07:00	13.9	7	*1/8"	26	45	180	875	2100	50.4	51.3		0	OIL PRESSURE SWITCH PROBLEM
	08:00	14.9	8		34	45	180	880	2500	51.8	52.1	5.2	2500	2000 TO 2500 4 MINS 42 SECS 37.6 ACFM
	09:14	15.9	9		34	45	180	900	2500	70.2	55.1		2500	
	10:18	16.9	10		34	45	180	875	2100	66.7	58.8		1755	
	11:30	17.9	11		34	46	180	875	2500	62.8	63.9	5.2	2500	2000 TO 2500 4 MINS 33 SECS 38.8 ACFM
	12:36	18.9	12		34	46	180	900	2400	73.9	68.3		2400	
	13:40	19.9	13		34	46	180	875	2200	72.5	68.6		2150	SECOND STAGE GAUGE FOGGED UP
	14:46	20.9	14		34	46	180	880	2500	70.3	64.5		2500	
	15:10	21.9	15		34	46	180	900	2300	69.6	57.3		2200	
16 NOV 89	17:30	22.9	16		34	46	180	900	2500	70.3	53.6	5.2	2500	2000 TO 2500 4 MINS 53 SECS 36.2 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
17 NOV 89	06:00	22.9	16	*1/4"	30	45	180	875	2100	26.3	37.8	5.2	1000	
	06:15	23.2	16.15		32	45	180	900	2500	54.4	37.6	5.2	2500	2000 TO 2500 4 MINS 28 SECS 39.6 ACFM
	07:10	23.9	17		34	45	180	875	2200	51.6	40.3		1800	
	08:18	24.9	18		34	45	180	900	2200	47.8	41.1		1950	
	08:24	25	18:06		34	46	180	900	2100	47.7	41.4		1250	STOP TEST 25 COMPRESSOR HRS OIL CHANGE &
	11:15	25	18:06	FULL	42	46	180	900	2200	32	52.1		1250	FILTER FL-400A ANDROL 750
	12:20	25.9	19		38	46	180	900	2500	65.9	52.3	5.2	2500	2000 TO 2500 4 MINS 31 SECS 39.2 ACFM
	13:32	26.9	20		36	46	180	900	2100	69.7	56.6		1750	
	14:43	23.9	21		36	46	180	900	2500	65.3	53.9		2500	
	15:50	28.9	22		36	46	180	900	2100	61.2	51.7		1600	
17 NOV 89	17:12	29.9	23		36	46	180	900	2500	66.3	50.2	5.2	2500	2000 TO 2500 4 MINS 38 SECS 38.2 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
20 NOV 89	05:30	29.9	23	FULL	36	45	180	875	2100	52.1	53.2		2000	
	05:36	30	23:06		36	46	180	900	2500	66.9	53.2	5.2	2500	2000 TO 2500 4 MINS 46 SECS 37.1 ACFM
	06:41	30.9	24		36	46	180	875	2100	42.1	52.4		800	
	07:41	31.9	25		36	46	180	900	2400	71.1	62.7		2400	25 HR TEST AIR SAMPLE
	08:50	32.9	26		36	46	180	900	2500	78.5	68.1		2500	
	09:12	33.9	27		36	46	180	900	2500	81.1	65		2500	
	10:18	34.9	28		36	46	180	900	2600	83.7	70.6		2600	HAD TO RESET PRESSURE SWITCH
	11:40	35.9	29		38	46	180	900	2500	86.8	71.4	5.2	2500	2000 TO 2500 4 MINS 42 SECS 37.6 ACFM
	13:00	36.9	30		38	46	180	890	2100	75.2	72.6		1650	
	14:08	37.9	31		38	46	180	890	2300	76.7	73.4		2250	
	15:10	38.9	32		38	46	180	890	2000	75.2	66.9		1500	
	16:20	39.9	33		38	46	180	890	2100	73.9	65.3		1900	
20 NOV 89	17:30	40.9	34		38	46	180	890	2500	72.5	64.7	5.2	2500	2000 TO 2500 4 MINS 39 SECS 38.0 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS 1	2	3	4	DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
21 NOV 89	05:30	40.9	34	FULL	36	46	180	890	2000	59.1	62.5		1000	HAD TO RESET BACK PRESSURE
	06:45	41.9	35		36	46	180	900	2500	78.6	63.3	5.2	2500	REGULATOR 2000 TO 2500 4 MINS 45 SECS 37.2 ACFM
	08:04	42.9	36		38	46	180	900	2500	82.5	70.2		2500	
	09:10	43.9	37		38	46	180	900	2500	85.9	76.7		2500	
	10:20	44.9	38		38	46	180	890	2100	88.2	81.4		1600	
	11:30	45.9	39		38	46	180	900	2500	75.7	80.1		2150	
	12:40	46.9	40		38	46	180	900	2500	92.4	77.9	5.2	2500	2000 TO 2500 4 MINS 43 SECS 37.5 ACFM
	13:44	47.9	41		38	46	180	900	2500	90.3	76.4		2400	
	15:00	48.9	42		38	46	180	900	2100	72.6	73.3		1000	
	15:14	49.9	43		38	46	180	900	2500	91.2	73.1		2500	
	17:12	50.9	44		38	46	180	900	2500	87.3	69.9		2400	
21 NOV 89	18:15	51.9	45		38	46	180	900	2500	80.8	67	5.2	2500	2000 TO 2500 4 MINS 44 SECS 37.3 ACFM

DATE	TIME	TOTAL METER HOURS	TOTAL TEST HOURS	OIL LEVEL	OIL PRESS.	STAGE PRESS				DISC AIR TEMP.	AMBIENT AIR TEMP.	FLASK SIZE	FLASK PRESS.	REMARKS
						1	2	3	4					
22 NOV 89	05:30	51.9	45	ADD ONE PINT	36	45	180	875	2000	62.7	69.4		1000	
	06:40	52.9	46		38	45	180	900	2500	78.9	64.8	5.2	2500	2000 TO 2500 4 MINS 44 SECS 37.3 ACFM
	07:42	53.9	47		38	46	180	900	2250	82.8	68		2000	
	08:54	54.9	48		38	46	180	900	2500	86.4	71.7		2500	24 HR AIR SAMPLE
	10:00	55.9	49		38	46	180	900	2100	88.5	72.1		2000	
	11:15	55.9	50		38	46	180	900	2500	86.1	72.3	5.2	2500	2000 TO 2500 4 MINS 41 SECS 37.7 ACFM
														TOOK 50 HRS AIR SAMPLE

1 Hour

Memorandum 15 Nov 1989

To: Dave Sullivan, EDU
From: Glen Deason, Code 5130

Subject: Results of air sample from Bauer compressor. This was the one hour test. Test number 89-48.

1. In accordance with your request, on 15 Nov 1989 the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	362 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	3.4 PPM
Total Halogens**	<0.5 PPM
Methane	3.4 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

Memorandum 20 Nov 1989

To: Dave Sullivan, EDU
From: Glen Deason, Code 5130

Subject: Results of air sample from Bauer compressor. This was the twenty-five hour test.

1. In accordance with your request, on 20 Nov 1989 the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	392 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	3.6 PPM
Total Halogens**	<0.5 PPM
Methane	3.6 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.3 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

Memorandum 27 November 1989

To: Dave Sullivan, NEDU
From: Glen Deason, Code 5130

Subject: Test results of air sample from Bauer compressor after 50 hours.

1. In accordance with your request on 27 Nov 1989, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Air Sample
Oxygen	21.0%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	348 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	2.1 PPM
Total Halogens**	<0.5 PPM
Methane	2.1 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
C4+	<0.1 PPM

*Expressed as methane equivalents.
**Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist